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Structural study Using 2D Seismic Reflection Data of East lake Razzazah Area, Central Iraq

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Abstract

This research is focused on an interpretive of 2D seismic data to study is reinterpreting seismic data by applying sufficient software (Petrel 2017) of the area between Al-Razzazah Lake and the Euphrates river belonging to Karbala'a and Al-Anbar Governorates, central Iraq. The delineation of the sub-surface structural features and evaluation of the structure of Najmah and Zubair Formations was done. The structure interpretation showed that the studied area was affected by normal fault bearing (NW-SE) direction with a small displacement. In contrast, time and depth maps showed monocline structures (nose structures) located in the western part of the studied area.

Keywords: 2D seismic data, Zubair, Najmah, Razzazah area, and Monocline structure.

دراسة تركيبية بإستخدام البيانات الزلزالية الانعكاسية ثنائية الابعاد لمنطقة شرق بحيرة الرزازة وسط العراق

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الخلاصة

يركز هذا البحث على تفسير البيانات الزلزالية ثنائية الأبعاد الهدف من الدراسة هو إعادة تفسير البيانات الزلزالية من خلال تطبيق برنامج البترل للمنطقة الواقعة بين بحيرة الرزازة ونهر الفرات التابعة لمحافظتي كربلاء والأنبار وسط العراق. تم تحديد السمات الهيكلية تحت السطحية وتقييم هيكل تكوينات نجمة والزبير باستخدام البيانات الزلزالية ثنائية الأبعاد. أظهر نتائج التفسير التركيبي أن المنطقة المدروسة متأثرة بثلاثة صدوع احدها فقط يصل الى العواكس المدروسة وهو صدع اعتيادي يحمل اتجاه شمال غرب – جنوب شرق بأزاحة صغيرة. بينما أظهرت خرائط الوقت والعمق تراكيب أحادية الخط (خشوم تركيبية) تقع في الجزء الغربي من منطقة الدراسة.

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Introduction

Seismic interpretation is the art and science of inferring geology from the processed seismic record. The process of interpretation can be divided into three related categories: structural, stratigraphic, and lithology. The structural seismic interpretations help create structural maps of the subsurface from the observed configuration of arrival times [1]. Seismic reflections come from interfaces where the rocks acoustic properties change, which is the key to our understanding of the nature of seismic data. The acoustic impedance of a rock layer is the product of that layer's density and velocity, and strictly a reflection is generated by contrast in acoustic impedance. In fact, impedance and lithology normally follow each other so that impedance boundaries and lithologic boundaries normally concur [2]. The 2D seismic interpretation has been used in many areas, such as in the Khan Al-Baghdady area, where the study showed that the Akkas field contains gas accumulation [3], while in the east Nasiriya, the 2D seismic interpretation shows that the area is a promising hydrocarbon region [4] This is due to the appearance of some stratigraphic features in many seismic lines.

Description of the Studied Area

The studied area is located in the central part of Iraq between Karbala'a and Al-Anbar governorates, bordered by Razzazah Lake from the west and Euphrates River to the east. Tectonically, it lies on the Stable Shelf between the Mesopotamian zone and Al-Salman Zone, which is placed between two fault systems (Ramadi-Musayib fault in the east, which belongs to the Najd Fault system and the Kut-Dezful fault in the south as well as Sirwan fault in the north which belongs to Transversal fault system. The fault that detects in an area trending NW-SE parallel to the Najd fault system) [5] (Figure 1).

It is a flat area rising from 20-90 m above sea level towards the Euphrates River, covered with Miocene to Holocene sediments represented by restricted marine and continental deposits [6]. This area has been studied previously by [7], who used a gravity method on the area to investigate and determine the morphology of the basement rock and the possible effects imposed on their features by the deep-seated faults. In addition, [8] studied the geomorphology of Tar Al-Sayed and Tar Al-Najaf to understand the origins and development of the two cliffs. [9] The East Razzaza was investigated using the seismic technique to ascertain the seismic stratigraphic architecture and facies alterations in the Zubair, Yamama, and Gotnia formations in the region covered by a two-dimensional survey [9].

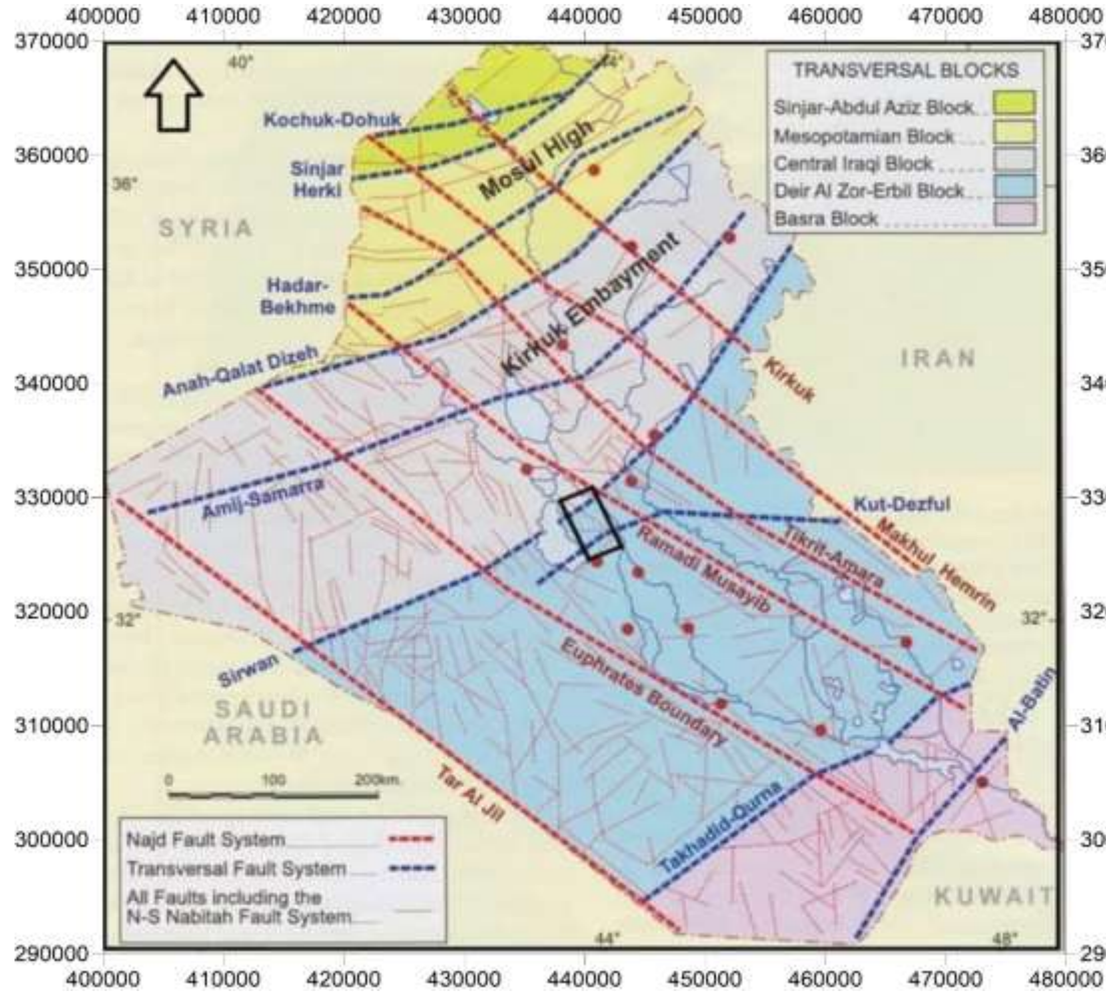

Figure 1-Location of the study area and the tectonic map of Iraq [5]

Horizon Picking

Picking is the process of identifying the seismic section reflection. It entails identifying whether wobbles from one trace to the next originate from the same reflection interface or the same rock layer [10]. A synthetic Seismogram of the Aq-1 well is made after determining the location of the reflectors; the survey lines are connected to a process called composite lines of the seismic section. The well of Aq-1 has been utilized to monitor and follow the reflectors. Each reflector was tracked in conjunction with the composite (Figure 2) and then worked to pick the formations (Top and base of the Zubair and Najmah Formations, according to the current study) is defined as marking the reflection on a seismic section. In Petrel, the piking of horizons is in several types, the most important of which is manual picking (it needs time, operate manually, the most effective and accurate method) which was used in the current study. The auto picking is operated by software, fast and less accurate. It represents the second type of picking.

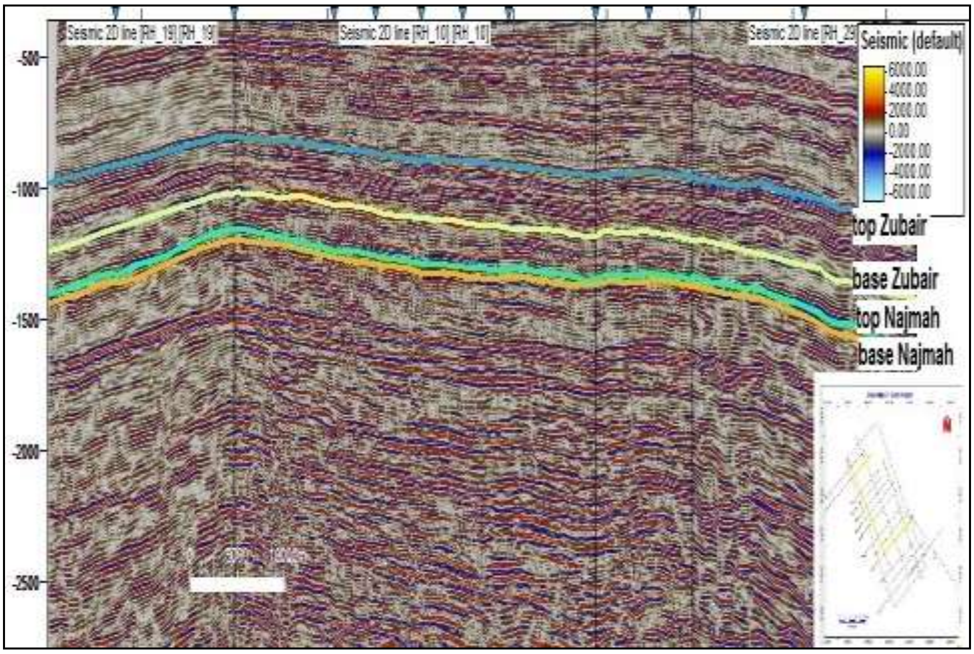

Figure 2-Reflectors of top and base of Zubair and Najmah Formations within the current study.

Delineation of Seismic Reflectors

Matching the same reflectors at the intersection points and the reflector quality is briefly explained below:

Four reflectors have been picked in this study which comprise: the top of Zubair, the base of Zubair, the top of Najma, and the base of Najma reflectors.

1. Reflectors Continuity: continuity of the picked reflectors, labelled on the seismic section, can be described as follows: The top of Zubair is good to very good continuity, while the base of Zubair, top of Najmah, and base Najmah have intermediate to good continuity.
2. Reflectors Concordance: The concordance of all picked reflectors was intermediate.
3. The quality of the reflectors: In general, the reflectors shown on the seismic section can be considered good to intermediate.
4. As a consequence of the negative reflectance between limestone and sandstone, the top of Zubair is selected as a trough, whereas the base of Zubair, the top of Najmah, and the base of Najmah are selected as peaks.

Seismic-Structural Pictures of the Picked Horizons

In addition, for the definition of the studied reflectors using synthetic seismogram in the time domain for Afaq-1 well, and based on the analysis of the seismic data and synthetic seismogram that recognized and picked within the Zubair and Najmah reflectors, these reflectors have been picked to prepare the time maps, which are converted later to structural maps in the depth domain by using velocity data of these reflectors. The two-way time (TWT) maps have been created. TWT, Average velocity, depth, and isopach maps have been constructed using the sea level as their reference datum.

Faults Recognition and Horizons Picking

The faults were picked along each strike and dip lines within the study area. Observed that the studied area has been affected by three faults, one of them reaches the studied reflectors. It is an NW-SE normal fault with a small displacement and is parallel to the collision suture between the Arabian and Iranian plates. Figure 3 shows that the studied area was affected by two types of faults (basement fault or shallow fault). So, the first fault may belong to either the Najd fault system (Precambrian faults) or the Abu-Jir fault, located to the west of the studied area.

The development of normal faults and their formation is caused by the consequence of a tensional force pulling the rocks apart. Probably because there is an intrusion twisted the rock up, causing it to split into two pieces, one of which slips down lower than the other. Normal faults account for the vast majority of traps found in oil exploration (Figures 4 and -5).

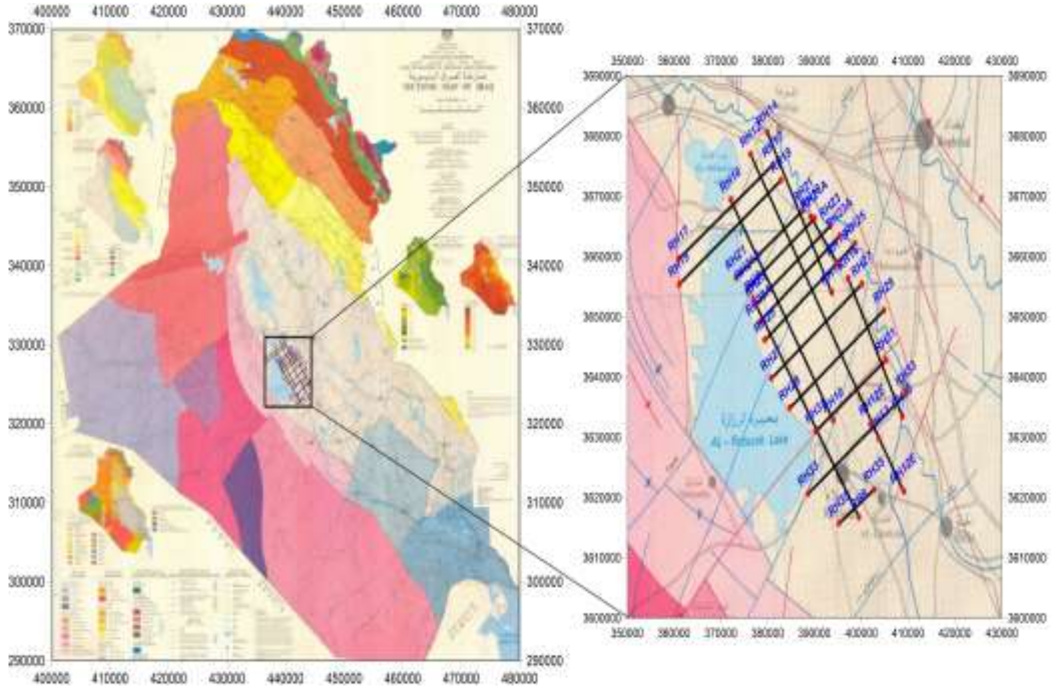

Figure 3- Tectonic map shows the studied area (After [11]).

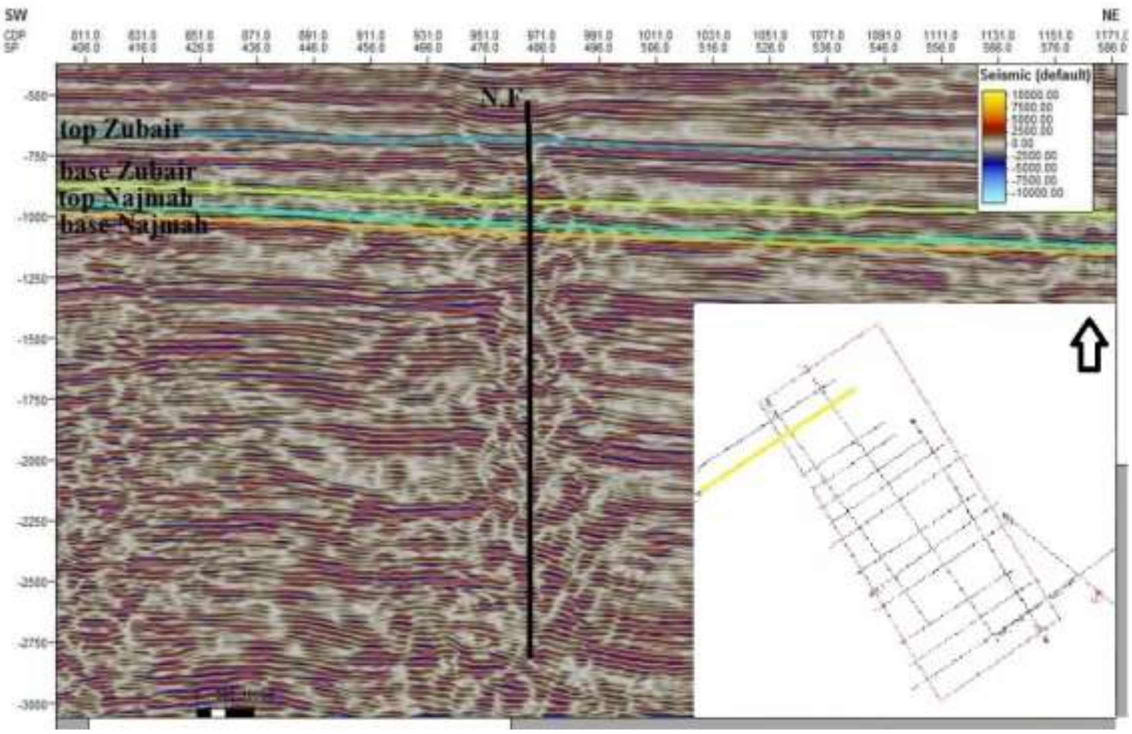

Figure 4- Seismic section with picked fault and horizons.

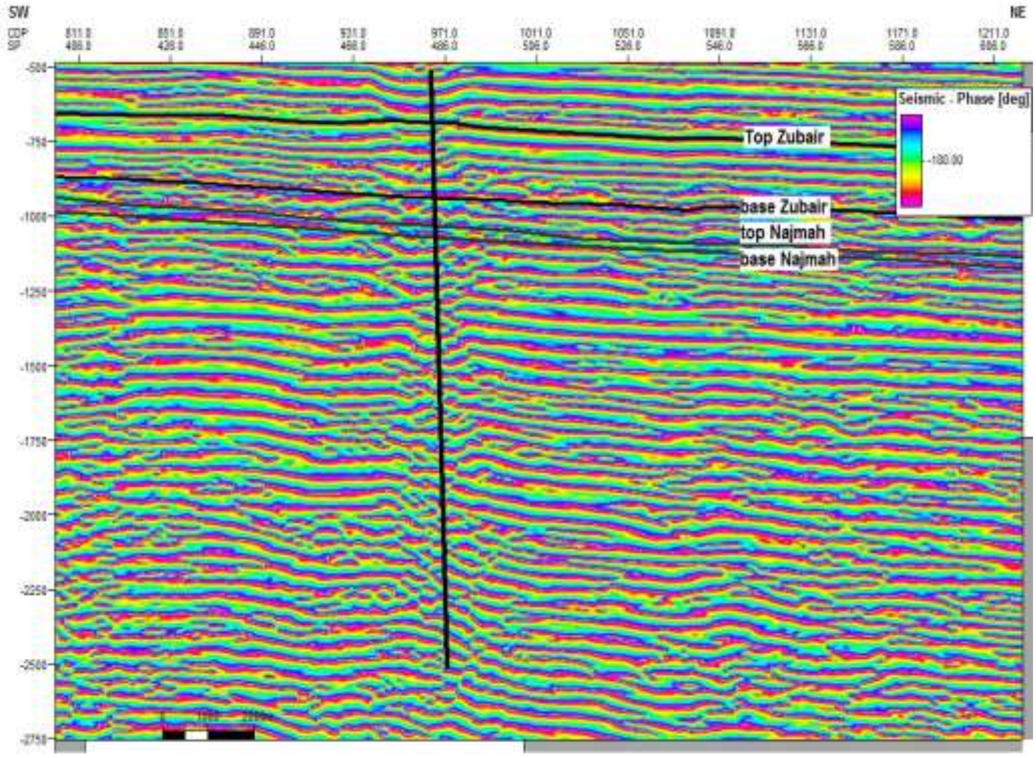

Figure 5- Instantaneous phase seismic section with picked fault and horizons

Two Way Time (TWT) Maps

Four TWT maps were created from the investigated reflectors, top Zubair, base Zubair, top Najmah, and base Najmah. The time maps may include significant information about the underlying geological feature, and it aids in understanding the time dipping of the reflectors in milliseconds [12]. The following represents a description of these maps.

-TWT Map of Top Zubair Formation

The map represents the TWT between the sea level as a reference surface and the top of the Zubair Formation, which is picked as a trough due to negative reflectivity between the limestone and sandstone. Figure 6 shows that the dominated dip trend of the area is toward SE and the lowest value of TWT is located in the northwest of the studied area (920 ms) with a contour interval (20 ms). Also, the highest time value is to the southeast of the map (1360 ms). The map is dominated by two (noses) structures named A and B located at the northeast of the studied area at a time value (920 - 1080 ms). The first one (A) is trending E-W, and the second (B) is trending SE-NW. The increasing of TWT means the seismic wave takes an extra time to return to the surface because the reflector is getting deeper.

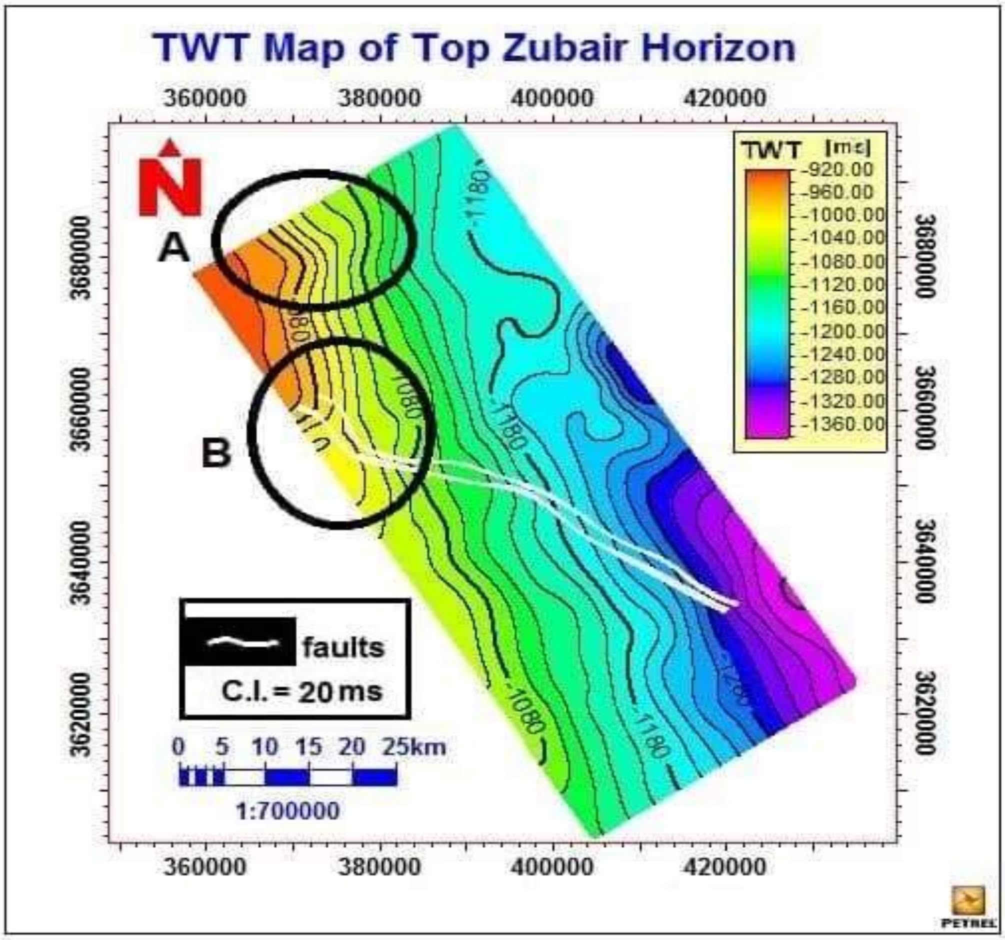

Figure 6- TWT map of top Zubair Formation.

The TWT between the reference surface, which is represented by sea level and the base of the Zubair Formation, which is picked as a peak, is shown in Figure 7. The dip of this layer begins from the northwest (1020 ms) and decreases gradually towards the southeast (1620 ms) with a contour interval (20 ms). That means the shallowest point is located northwest of the studied area. There are many monoclinal structures (nose structures) named A and B located on the west and northwest side of the studied area that were explained as follows: the first one (A) is trending E-W and the second (B) trending S-N (1020-1240 ms).

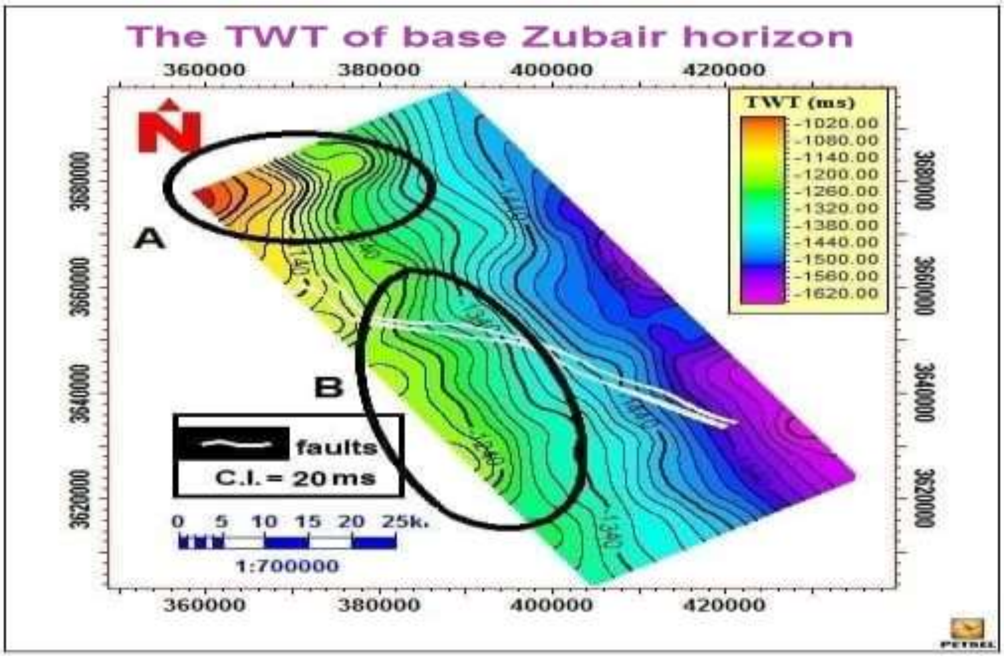

Figure 7- TWT map of Base Zubair Formation.

TWT map of the top of the Najmah Formation

The time shown on this map represents the arrival time of the seismic waves from sea level to the top of the Najmah Formation (Figure 8). The layer is dipping from northwest to southeast at a value (1500ms-1980 ms) at a contour interval (20ms). The structural picture represented a regional monoclinic structure with some nose structures A and B located northwest of the studied area trending E-W between (1500-1620ms).

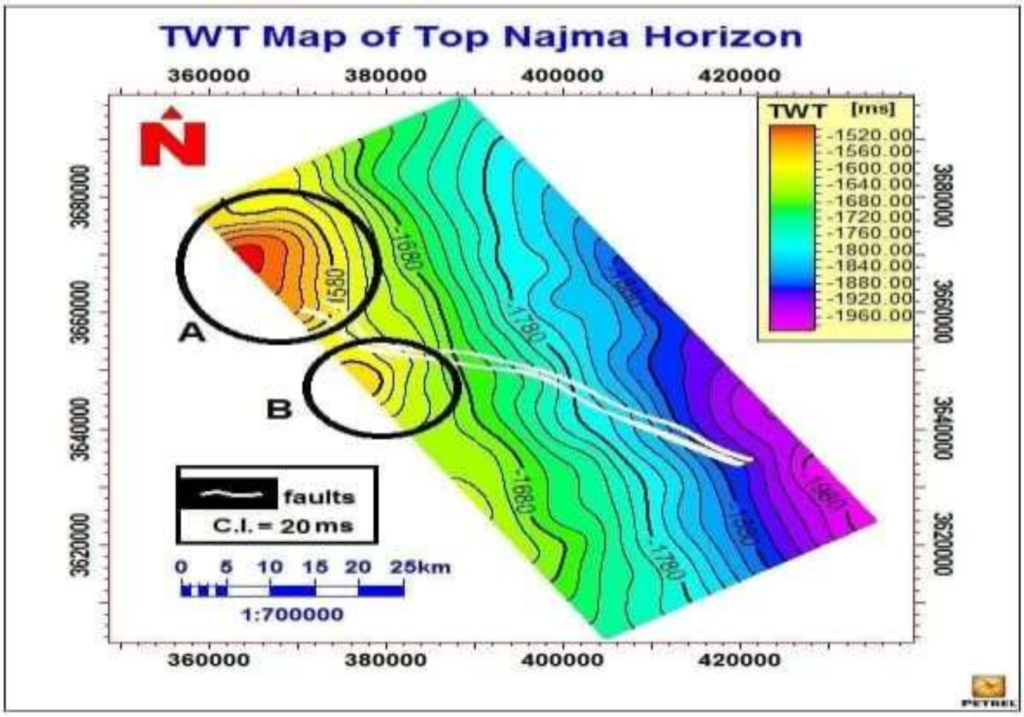

Figure 8- TWT map of top Najmah Formation.

- TWT map of base of Najmah Formation

Figure -9 represents the TWT map between sea level and the top Gotnia horizon. The lower value of TWT can be observed in the southeast direction (2000 ms), and it increases in the northwest direction (1560 ms). The nose structures A and B observed in this map lay northwest of the studied area and bearing E-W between 1560-1660 ms**.**

Velocity Maps

The average velocity maps generally showed increases in velocity with depth irregularly due to the heterogeneity of the sedimentary layers as a result of face change and depositional system. The velocity maps (Figures 10 and 11) show an increase in the average velocity values toward the south direction while decreasing in the north and northeast direction in Najmah Formation while Zubair Formation gives a high velocity in the north, west, and south whereas it decreases to the east and southeast. The increase in velocity reflects the direction of the sedimentary basin center. The magnitude of average velocity for Zubair Fn. ranged from (3000 m/s - 3280m/s) while the average velocity of a base of Najmah Fn. ranged from (3200 - 3480 m/s).

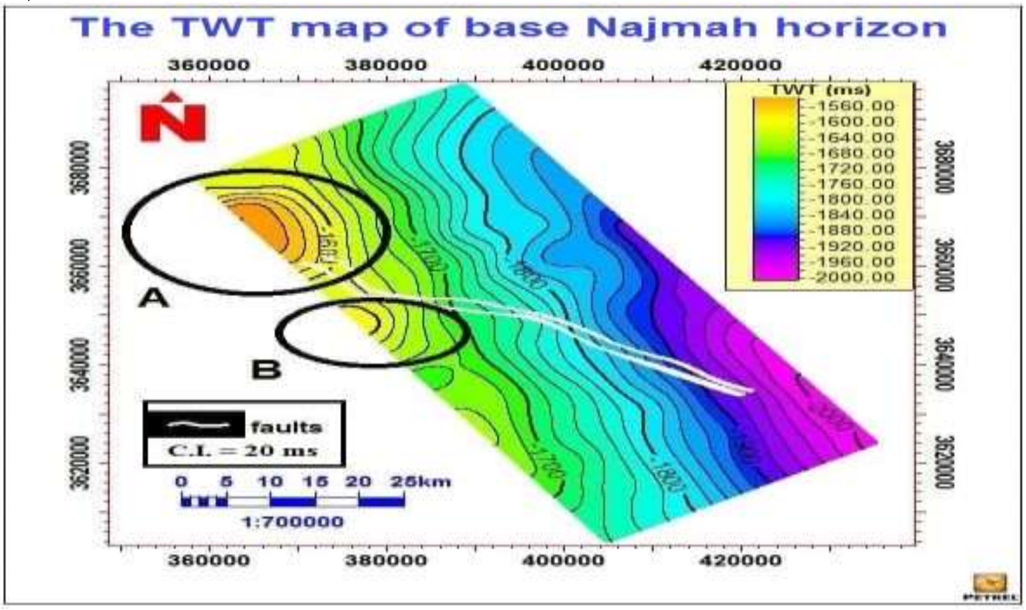

Figure 9- TWT map of base Najmah Formation.

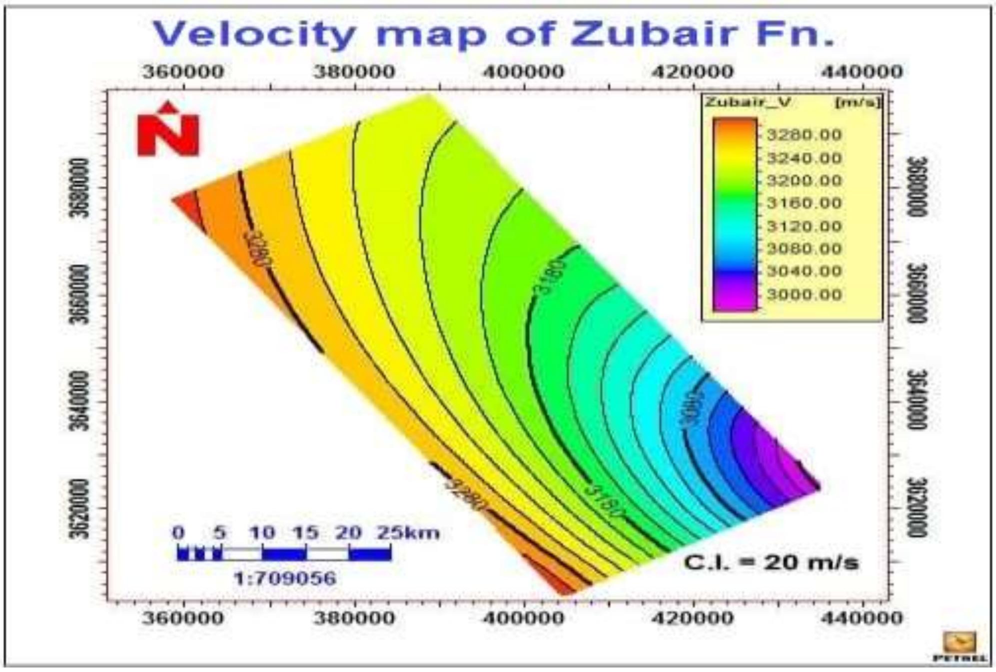

Figure 10-Average velocity map of Zubair reflector.

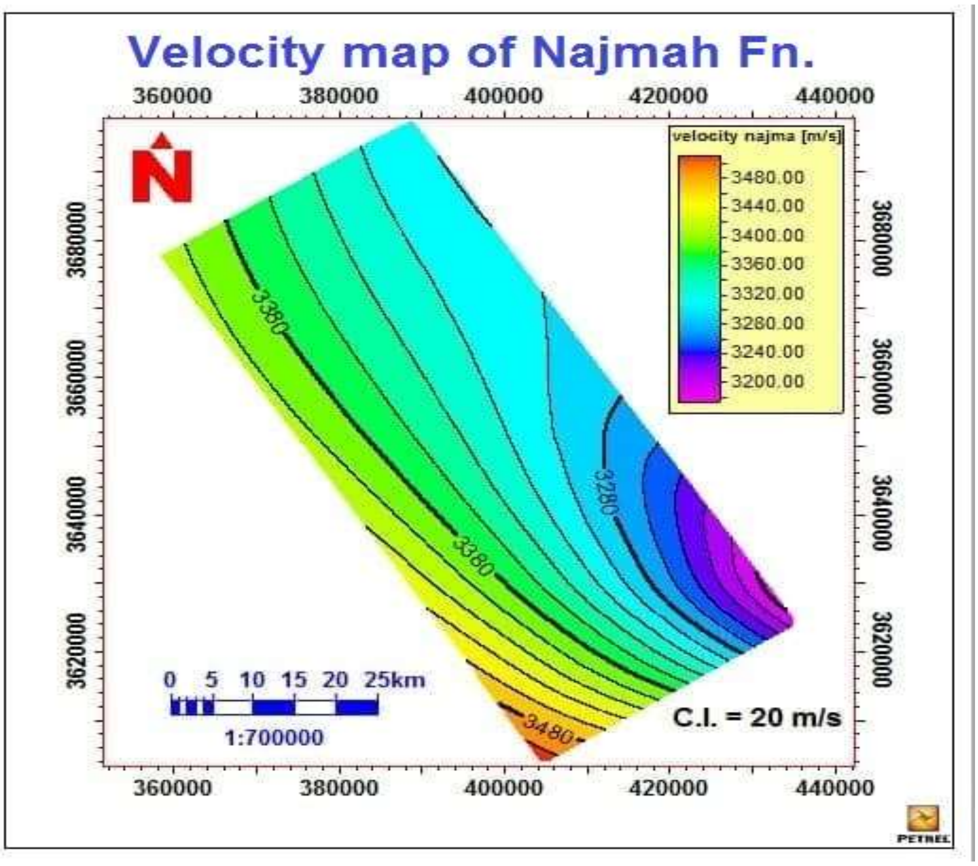

Figure 11- Average velocity map of Najmah reflector.

Depth Maps

The depth map can be calculated by processing velocity maps with time maps for (top Zubair, base of Zubair, top Najmah, and base Najmah Formations). At each location, the depth is equal:

(The average velocity × TWT /2) [13].

Top Zubair Fn. depth map

Figure 12 shows the general depth trend in the SE direction for the top of the Zubair Formation. The lowest depth value (1560m) is seen in the northwest and progressively rises toward the south and southeast to achieve a contour depth of (2040m). The interval between contours is 20 m. There are many nose structures (A, B, C, D, and E) placed in the northwest and southwest of the studied area and explained as follows:

A. Trending E-W between 1560 to 1780 m.
B. Trending SE-NW between 1580-1680m.
C. Trending E-W between 1780-1880m.
D. Trending E-W between 1780-1960m.
E. Trending S-N between 1780-1880m.

Base Zubair Fn. depth map

The base Zubair Formation depth map is shown in Figure 13. The higher depth is in the east and southeastern part of the map, which reach about (2600m) depth and gradually decreases to the northwest (1700m). Structural noses observed in the map in the northwest and southwest of the studied area which refers to structural features (A, B, C, D, E, F, G, and H) trending E-W between 1700-2340m except G and H ranged between 2340-2440m. Only one nose (E) trends SW-NE.

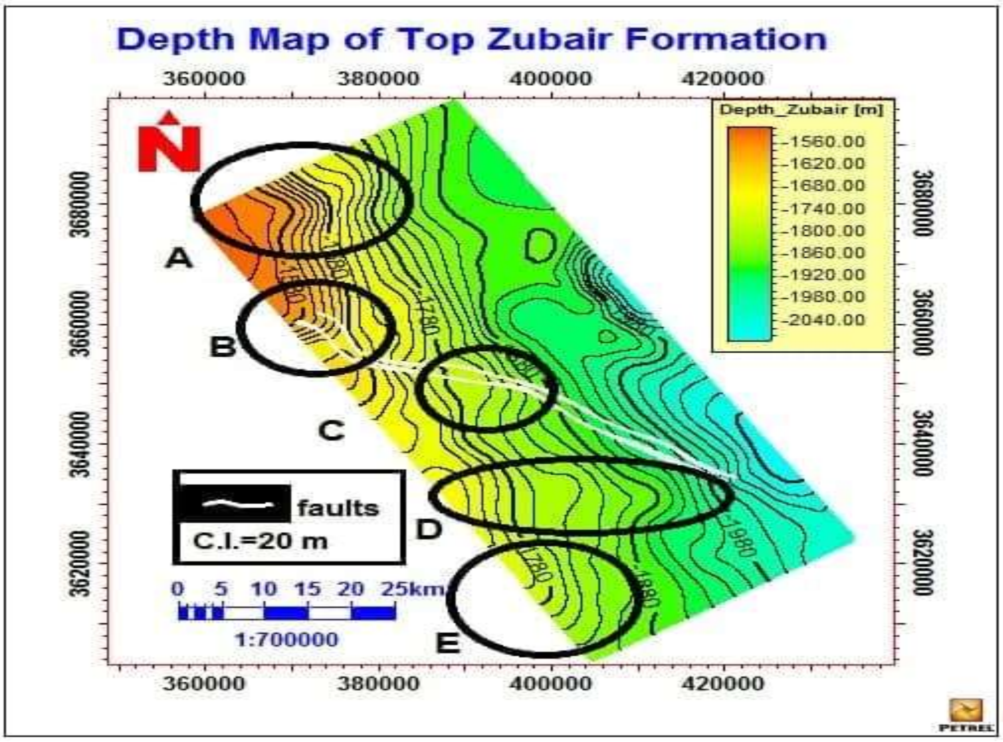

Figure 12- Depth map of Zubair reflector.

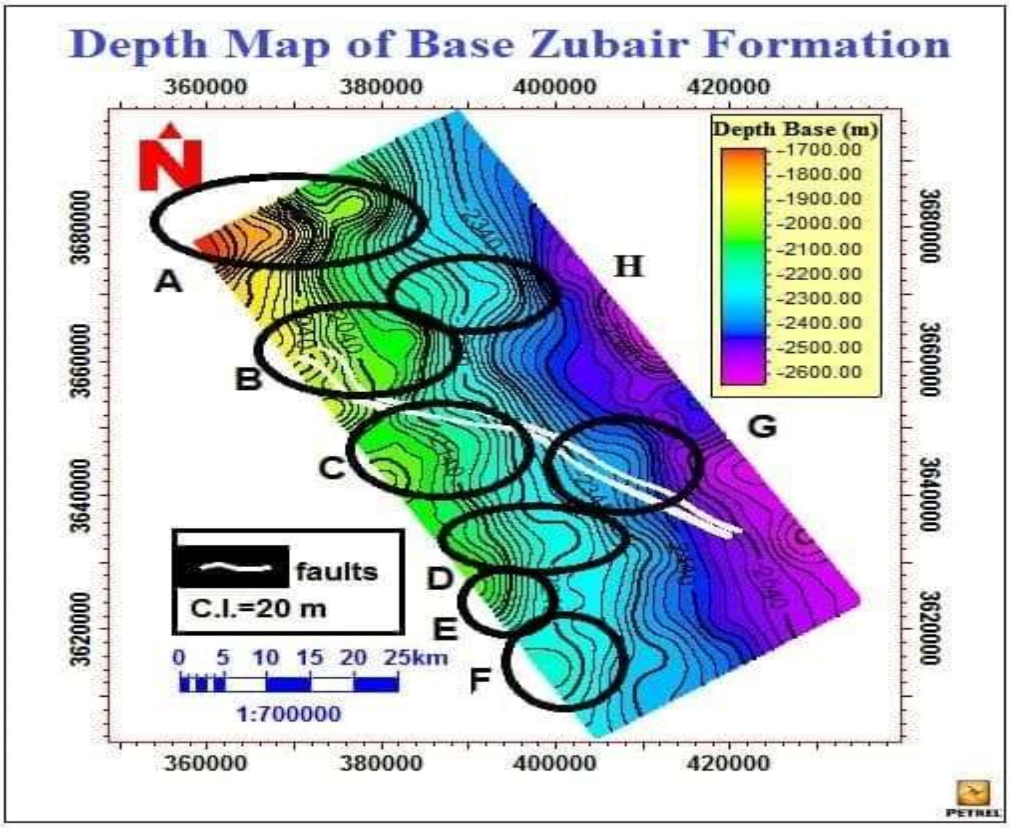

Figure 13- Depth map of base Zubair reflector.

-Top Najmah Formation. Depth Map

Figure 14 shows the general depth trend towards SE for the top of the Najmah Formation. The shallowest point (2580m) is found in the northwest and progressively rises in the east and southeast to reach (3180m). Structural Noses observed in the map refer to structural features located at the W, NW, and S part of the studied area (A, B, C, and D), which are explained as follows:

(A) Is trending NE-SW between (2580-2780m)

(B) Is trending E between (2580-2780m)

(C and D) are trending SE-NW (2860-3060m) with a contour interval of 20 m.

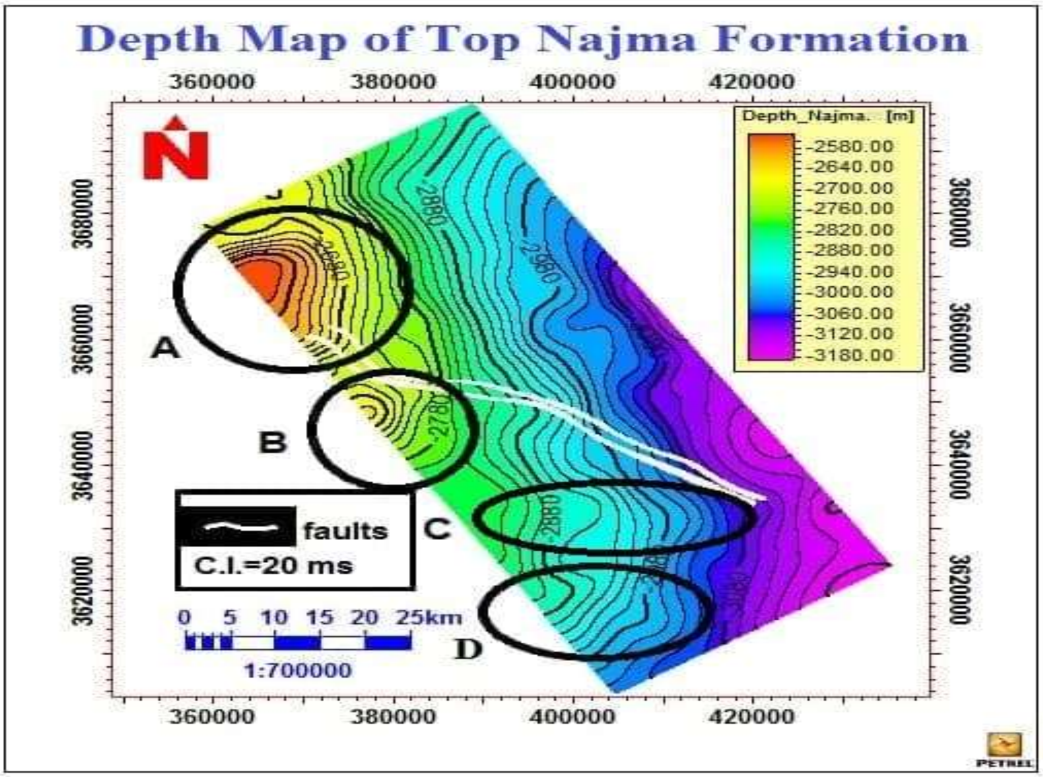

Figure 14-Depth map of top Najmah reflector.

- Base Najmah Formation. Depth Map

The same trend SE direction for the top of the Najmah Formation is shown in Figure 15. The shallowest point on the map (2640m) lay in the northwest and increased to (3180m) in the east and southeast direction. Contour interval 20 m. Structural Noses observed in the map refer to structural features in the NW and S parts of the studied area (A, B, C, and D). A bearing E-W between (2640-2900m), (B) is trending SE-NW between (2700-2800m) while C and D bearing E-W between (2880-3200m).

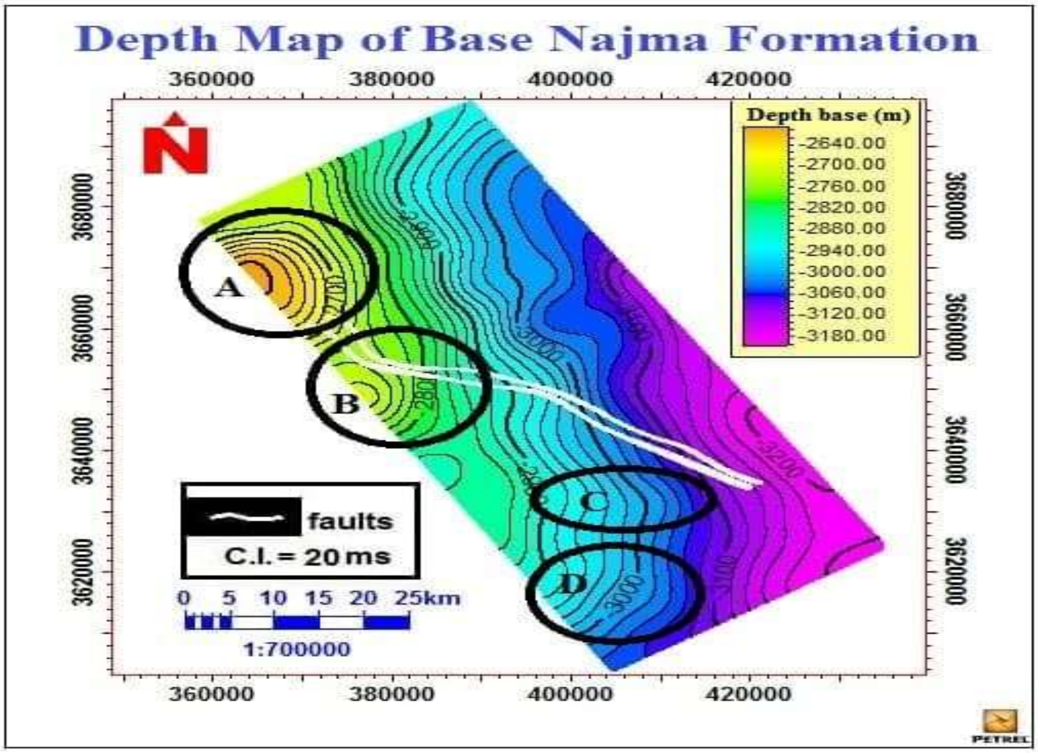

Figure 15- Depth map of base Najmah reflector.

Isopach Maps

-Zubair Isopach Map

Figure 16 shows the thickness of the Zubair Formation varieties from (400 - 800 m). It is noted that the maximum value of thickness is located in the northeast and southeast, while the minimum value is towards the west and northwest.

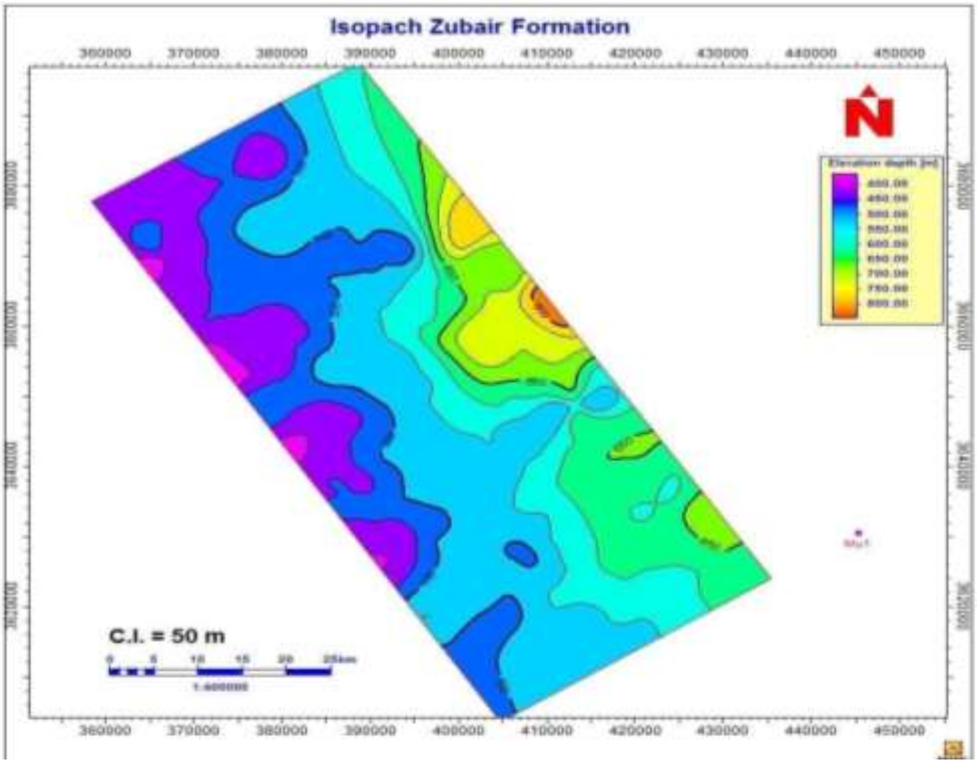

Figure 16- Zubair Formation Isopach map.

- Najmah Isopach Map

Figure 17 shows that the thickness of the Najmah Formation ranges from (15-90 m). It is noted that the thickness is stable at a value between 30 m to 60 m except for two points representing a thickening in the Najmah Formation located southeast and northwest of the studied area.

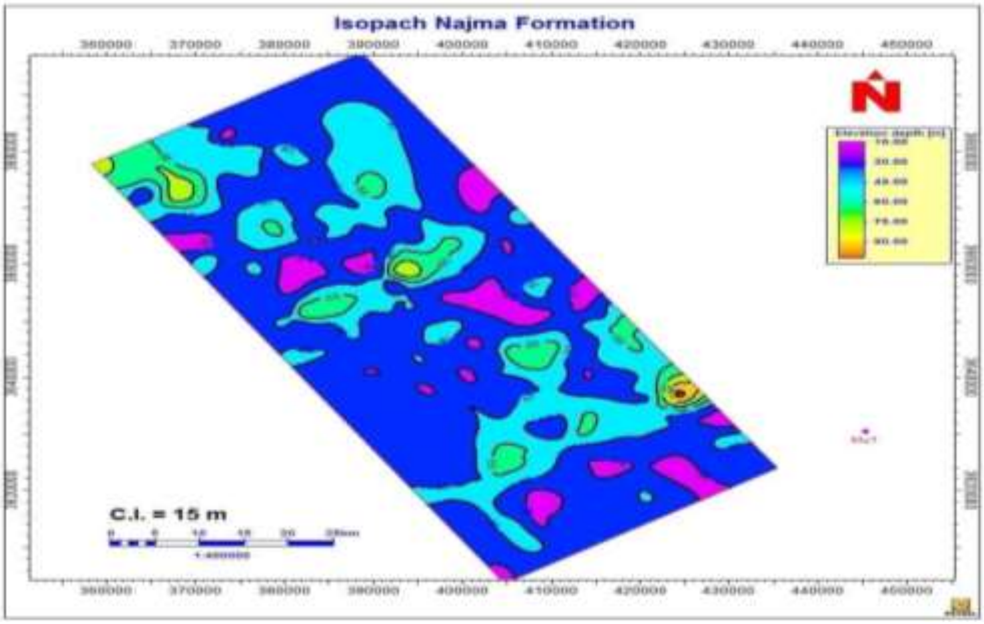

Figure 17-Najmah Formation Isopach map.

Isochron map

-Isochron map of Zubair Formation

The thickness of the Zubair Formation showed in Figure 18 in time domain values ranging from (150 - 350 ms). It is noted that there is an increase in time thickness toward the northeast and southeast of the studied area with contour interval (25 ms).

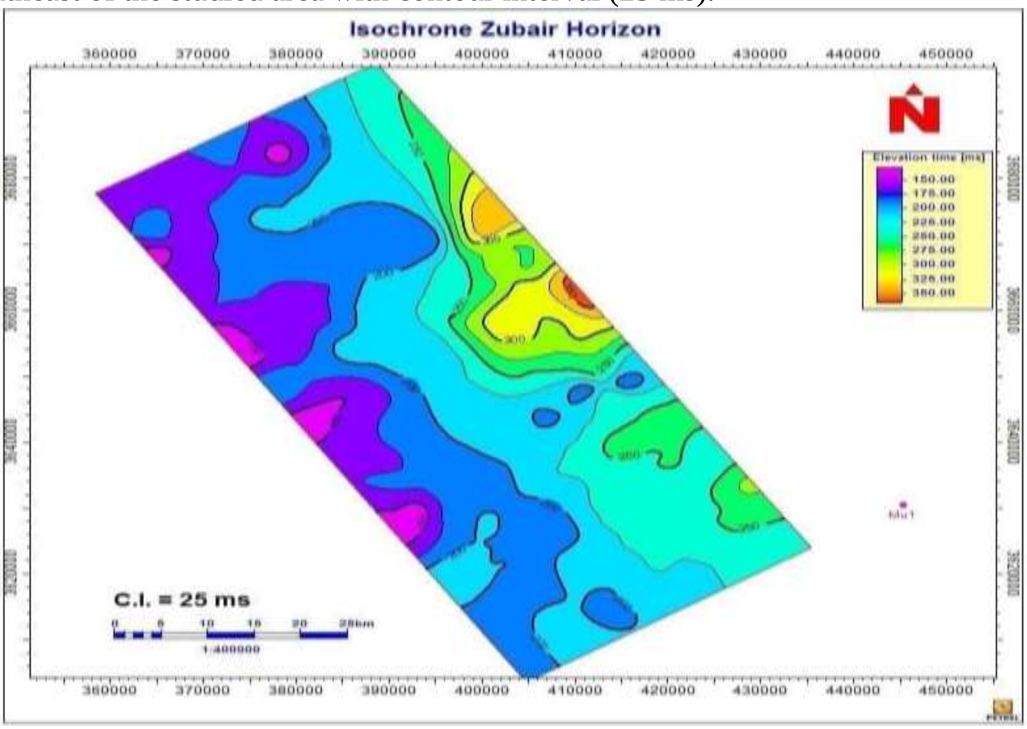

Figure 18-Isochrone Map of Zubair Formation.

- Isochrone map Najmah Formation

Figure 19 shows that the thickness values of the Najmah Formation range from (10-50 ms) with a contour interval of 5 ms. It shows that the dominant time thickness is between 10m to 25, except for two points located in the northwest and southeast, which appear to be higher time thicknesses.

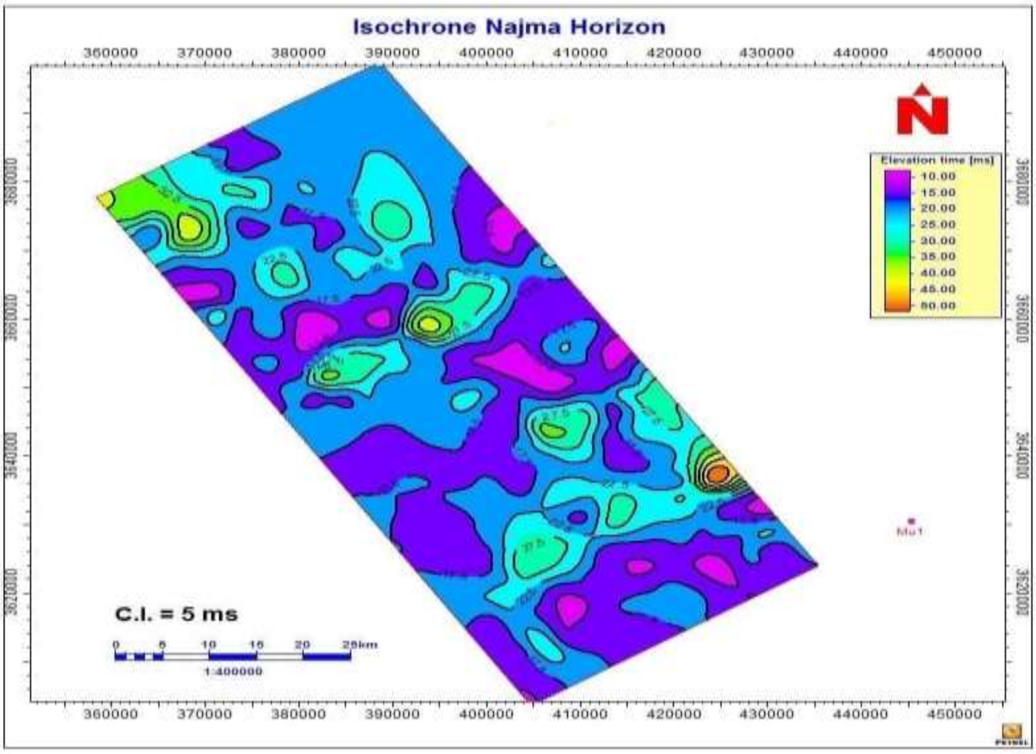

Figure 19- Isochrone Map of Najmah Formation

Conclusions and Recommendations

One fault affected the studied area; it is an NW-SE normal fault with a small displacement and parallel to the collision suture between the Arabian and Iranian plates. Which has formed due to tension stresses may belong to either the Najd fault system (Precambrian faults) or the Abu-Jir fault, located to the west of the studied area. The time and depth maps show many nose structures located at NW and SW. The studied reflectors are bearing E-W, NE-SW, and SE-NW with a general slope towards the southeast. These monoclinal structures are a result of the compressional tectonic phase in the Middle Cretaceous-Tertiary time. This is because of the convergence between Arabian Plate (AP) and adjacent plates. However, subduction of AP beneath Eurasian plate events has occurred. Velocity maps show an irregular increase with depth due to inhomogeneity of the sedimentary layers due to different facies and depositional environments.

For further future work, the following recommendations are important:

1. Re-interpretation of the NW and SE parts of the studied area using the available 3D seismic data. Structurally, the area is considered a promising hydrocarbon area; therefore, re-interpretation gives more details about apparent structural phenomena which are maybe closed outside the studied area to the northwest and define faults systems more precisely.
2. 3D interpretation of seismic data to obtain high-resolution power for recognizing a stratigraphic feature on the time sections and attributes section.

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